Maori Subsistence Change: Zooarchaeological Evidence from the Prehistoric Dog of New Zealand

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ZOOARCHAEOLOGICAL STUDIES OF WILD and domesticated animals demonstrate the diversity of information that can be obtained from their bones (Clutton-Brock and Grigson 1984; Davis 1987). The examination of species that were closely associated with prehistoric people is particularly useful, as those commensal species served past societies' economic, ceremonial, and industrial needs (Bartosiewicz 1984; Clutton-Brock 1981; Smith 1969). Much of the morphological variation found in commensal remains was once thought to be the result of purposeful human selection (Belyaev 1979; Bökönyi 1969; Scott 1955; Zeuner 1963). However, there is increasing data to suggest that it is the anthropogenic environment itself which sets many of the animals' morphological and behavioral parameters (Clutton-Brock 1992; Morey 1994; Tchernov and Horwitz 1991). Thus the geographic and temporal variation found in commensal remains will provide information about the animals themselves, but also has the potential to throw light on the prehistoric human environment in which they once lived. This paper suggests that the analysis of commensal remains, even at a coarse scale, has the capability to inform prehistorians of large-scale changes occurring in a prehistoric society.

In Oceania, work on the primary (Polynesian dog *Canis familiaris*, pig *Sus scrofa*, fowl *Gallus gallus*) and secondary (Pacific or Polynesian rat *Rattus exulans* or *concolor*) commensals has generally been limited to two approaches. The first of these involves the synthesis of historical and archaeological data to determine the animal's geographic and temporal distribution (Baldwin 1990; Cassels 1983; Kirch 1984; Urban 1961). The second approach is concerned with estimating prehistoric human subsistence from the identification and quantification of commensal remains from archaeological sites (Emory and Sinoto 1961; Kirch 1973; Rolett 1992). Morphological examination is surprisingly rare, given the early interest (Ball 1933; Miller 1906, 1924; Wood-Jones 1931) and the potential of such study (Wood-Jones 1929 : 329). In part, this lack of inquiry can be attributed to poorly

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excavated or curated remains, the dispersed nature of archaeological collections, and the often small sample size from an individual site or island. These difficulties aside, the diverse environments and cultures found in this region provide an opportunity to study commensal skeletal variation through time and between archipelagoes.

The Polynesian dog of New Zealand (*kuri*) has been the subject of study and discussion since the late nineteenth century. Interest in the *kuri* is due largely to it being the largest terrestrial mammalian carnivore in prehistoric New Zealand and to the fact that only the *kuri* and the Pacific rat were successfully established by Maori (Anderson 1990; Bay-Petersen 1984; McGlone et al. 1994). The demise of the *kuri*, caused by interbreeding with introduced European dogs (Anderson 1990; Colenso 1878), means that it is primarily through analysis of its biological remains that information about this extinct breed can be furthered. The archaeological utility of the *kuri* lies in its close association with Maori, as it was used for a number of purposes both functional and cultural (Allo 1970; Clark 1996; Luomala 1960; Schwimmer 1963).

PREVIOUS SKELETAL STUDIES

Initial research on *kuri* remains was undertaken by Julius Haast. He believed that the early "moa-hunters," in contrast to the later "Maori," did not possess a domestic dog. Although he was primarily concerned with the stratigraphic placement of dog-gnawn moa bone in prehistoric sites, it was Haast (1872) who made the first anatomical comments about the *kuri* crania and dentition, including noting the presence of supernumerary teeth. Initial osteometric work by Hector (1877) and Hutton (1898) followed, using archaeological material and remains from wild dogs thought to belong to the *kuri* breed. However, these examinations were preliminary and research focus turned to the contentious question of the date of *kuri* extinction. Debate was polarized between those advocating an early assimilation of the *kuri* into the gene pool of introduced European breeds between 1810 and 1830 (Cheeseman 1894; Colenso 1878, 1893) and those who suggested that remnants of the breed survived in remote areas into the latter half of the nineteenth century (Murison 1877; White 1890, 1894; Wilson 1913). This debate was never resolved and both views are present in recent literature (Anderson 1981*b*, 1990; Clark 1995 : 9–13; Johnston and Morton 1988 : 247; Temple 1985).

The archaeological study of *kuri* remains was pioneered by Allo (see also Fisher 1934), who, in a wide-ranging work, investigated *kuri* anatomy and diet and its economic and social place in Maori society (Allo 1970). Some of these themes have since been investigated in considerable detail (e.g., Byrne 1973; Clark 1997*b*; Coutts and Jurisich 1975; Smith 1981*b*; Williams 1980). One of Allo's major research goals was to examine *kuri* bones for any evidence of geographic or temporal variation. To do this, anatomical features were noted and skeletal measurements collected, along with observations about the cranial and mandibular dentition. Although marked size variation in cranial and post-cranial skeletal elements was found within archaeological sites, Allo considered that the difference represented the outer limits of normal size variation in a canine population. Specifically, it was "impossible to show any change from early to late sites. There seemed to be little difference between northern and southern sites" (Allo 1970 : 69).

In contrast to the limited information gained from osteometric study, features of the *kuri* dentition were found to display significant variation between prehistoric dogs from the North Island and those from the South Island. The degree of tooth wear, incidence of periodontal disease, and occurrence of premortem tooth loss differed between island populations. Dietary differences were thought to be responsible, with North Island dogs ingesting a greater proportion of soft vegetable foods, causing them to have little tooth wear, an absence of periodontal infection, and reduced premortem tooth loss compared to South Island *kuri* (Allo 1971).

By differentiating between congenital (inherited) and pathological (environmental) dental abnormalities, Allo suggested that the former provided a means of tracking the prehistoric occupants of an archaeological site. For example, mandibles possessing a supernumerary M_3 alveolus were found at the early sites of Wairau Bar and Marfells Beach but not at the nearby, but later, site of Mussel Point. This indicated that an economic relationship existed between the two localities containing the abnormality (Allo 1971 : 43). A number of researchers have subsequently analyzed the *kuri* dentition for congenital abnormalities using Allo's model (Anderson 1981*a*; Smith 1981*a*; Teal 1975). In some cases this has enabled preliminary statements to be made about contact between prehistoric groups (Davies 1980 : 81–90; Leach 1979 : 92–93), despite the fact that dental abnormalities, including supernumerary alveoli, have long been known to occur in members of the family Canidae (Huxley 1880 : 269; Mivart 1890). Studies have shown that supernumerary teeth can be caused by factors such as type of diet, trauma, and infection, as well as by genetic transmission (Hillson 1986; Wolsan 1984). Recent work (Clark 1997*a*, 1997*b*) has suggested that a supernumerary mandibular M_3 occurs in greater frequency in *kuri*, and possibly in other populations of Polynesian dogs, than in European breeds.

MATERIALS AND METHODS

In the current study, *kuri* skeletal assemblages from 37 archaeological sites—16 from the North Island, 20 from the South Island, and one from Stewart Island—were examined (Fig. 1). The antiquity of the sites spans the whole of New Zealand's known prehistory (Anderson 1991). The sites were divided into Davidson's (1984 : 223–224) chronological groups, Settlement (early prehistoric), Expansion (middle), and Traditional (late prehistoric), using criteria outlined in Clark (1995 : 250–279), including, where available, the results of radiocarbon dating, the presence of extinct fauna, the material culture assemblage, and interpretation of the site's age in the relevant literature. As stressed by Davidson (1984 : 222–223), these temporal groups are relative—rather than circumscribing strict chronological boundaries, they are analytic units that will require revision as new archaeological site information, particularly radiocarbon dates, is obtained. This flexibility is necessary given that the various regions of New Zealand are likely to have experienced differential Maori use depending on factors such as climate, population, and availability of faunal and industrial resources. Despite the use of these guidelines, there were difficulties in assigning some *kuri* remains to a chronological group, especially those from sites with evidence of multiple prehistoric occupation.

Measurements and observations from the major cranial and post-cranial skeletal

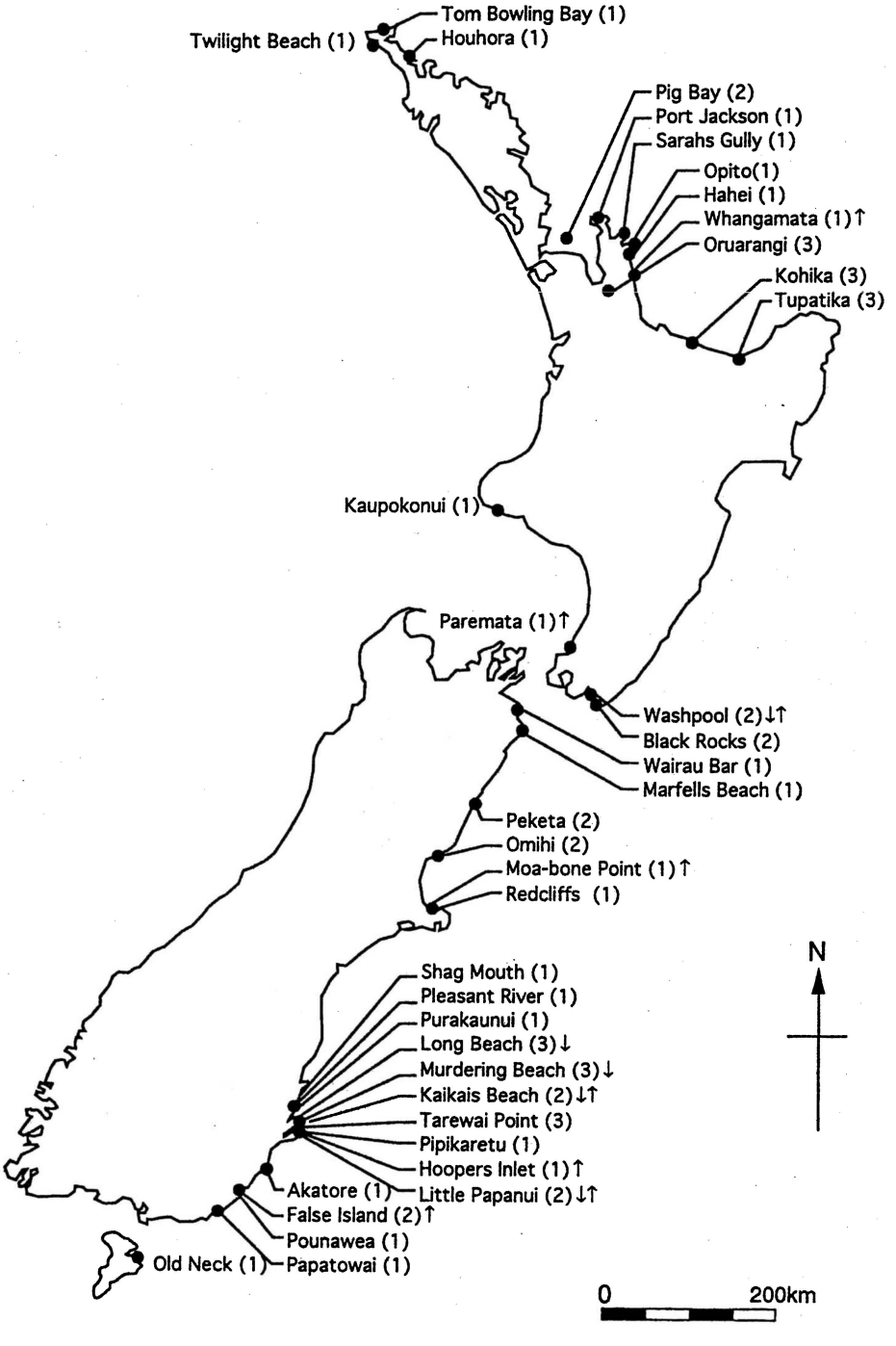

Fig. 1. Map of New Zealand, showing location of archaeological sites from which *kuri* assemblages were examined. Numbers in brackets refer to the chronological group in which the remains were placed (1 = Settlement, 2 = Expansion, 3 = Traditional). Arrows indicate the presence of early (↓) and late (↑) cultural material, illustrating the tentative nature of some assemblage classification.

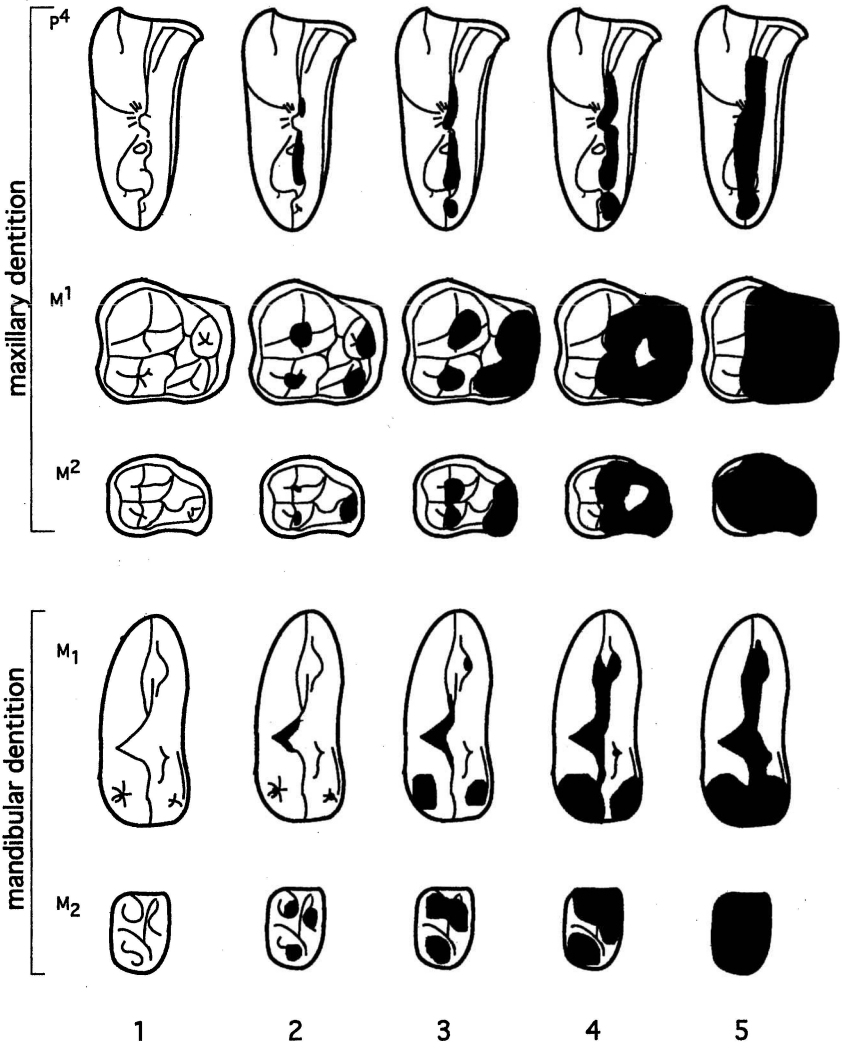

Fig. 2. Generalized view of tooth-wear scores (1–5) used to record wear on the *kuri* dentition.

elements of the prehistoric *kuri* population are presented elsewhere (Clark 1997*b*). Discussion here is limited to measurements and dental features that displayed the greatest degree of variation and had a sufficient sample number to allow statistical comparison. These were the midshaft diameters (medio-lateral [m-l], anterior-posterior [a-p]) of the forelimb (humerus and radius) and hind limb (tibia) and the degree of tooth wear found in the cranial and mandibular dentition. Measurements were taken with Mitutoyo calipers (± 0.01 mm). Percentage error rates for these measurements (after White and Folkens 1991 : 292) were between 0.70 percent (radius, m-l) and 1.99 percent (tibia, a-p). Tooth wear, shown in Figure 2, was recorded using a five-stage scoring system of the maxillary carnassial and maxillary and mandibular molar teeth. A score of 1 represented little or no visible wear and 5 severe tooth wear.

TABLE 1. ESTIMATES FOR THE TIME AND ORDER OF COMPLETE EPIPHYSIAL FUSION IN THE SKELETON OF THE MODERN DOG (AFTER SUMNER-SMITH 1966).

ELEMENT	PORTION	TIME (IN MONTHS)	ORDER OF FUSION
Scapula	Tuberosity	4–5	1
Humerus	Proximal	10	11
	Distal	5–8	3
Radius	Proximal	5–8	4
	Distal	6–9	8
Ulna	Proximal	5–8	2
	Distal	6–8	7
Femur	Proximal	6–9	9
	Distal	6–8	6
Tibia	Proximal	6–11	10
	Distal	5–8	5

Midshaft dimensions and tooth-wear data were placed, on the basis of their assemblage antiquity, into three chronological groups (Settlement, Expansion, Traditional) for statistical and graphical comparison.

Skeletal maturity of the post-cranial elements was assessed using the state of epiphysial fusion and the relative development of muscle attachment areas. Only dentitions with fully erupted molar teeth rows were examined for their degree of tooth wear. Thus analysis was probably confined to remains from dogs that had largely completed their skeletal development (subadult-adult). The technique of basing *kuri* skeletal maturity rates on the rates in modern dogs has been criticized on the grounds that the Polynesian dog may not follow a similar sequence or timing (Teal n.d.). At least in the New Zealand case, the sequence of epiphysial fusion and dental eruption was similar to that of European dogs. However, some epiphysial fusion estimates from modern dogs vary by up to 12 months. For example, fusion of the distal epiphysis of the radius is given by Sisson (1930) and Silver (1963) as occurring at between 16 and 18 months, whereas Sumner-Smith (1966) records complete fusion by six to nine months. It is considered that estimates of appendicular ossification detailed by Sumner-Smith (1966) are the most accurate and the most likely to reflect the approximate time of *kuri* skeletal development (Table 1). Sumner-Smith's study used radiographs from 281 dogs from 29 breeds and crossbreeds to determine the time of complete epiphysial union. Other studies (e.g., Hare 1960; Sisson 1930; Smith and Allcock 1960) had small samples, used a limited number of breed types, or used dissection to assess fusion. However, epiphysial-fusion figures should be used with some caution by archaeologists constructing canine age-at-death profiles or investigating site seasonality, as they are estimates that do not yet permit fine-grained distinctions.

As most *kuri* remains were found disarticulated in middens, it was not possible to directly assign a particular bone to a sex and no attempt has been made to control for this component of variation.

RESULTS

Midshaft dimensions from the humerus, radius, and tibia are presented first followed by the combined tooth-wear results for the mandibular and maxillary den-

TABLE 2. DESCRIPTIVE STATISTICS FOR *KURI* MIDSHAFT DIMENSIONS (ANTERIOR-POSTERIOR, MEDIO-LATERAL; MEASUREMENTS IN MM).

		n	MEAN	sd	MIN	MAX	Cv
Humerus							
Settlement (m-l)	$t = 8.78$	77	11.4	0.9	9.6	13.5	8.2
Traditional (m-l)	$p < .000$	28	9.8	0.8	8.6	11.8	7.8
Settlement (a-p)		77	16.2	1.7	12.5	20.4	10.6
Traditional (a-p)		28	13.6	1.6	10.8	17.7	11.4
Radius							
Settlement (m-l)	$F = 23.97$	49	13.2	1.8	9.8	16.5	13.5
Expansion (m-l)	$p < .000$	11	10.7	1.1	9.1	12.2	10.5
Traditional (m-l)		29	10.8	1.3	8.2	13.4	11.6
Settlement (a-p)		49	8.6	1.4	6.3	11.7	15.8
Expansion (a-p)		11	7.2	0.8	5.9	8.3	11.1
Traditional (a-p)		29	6.8	0.9	5.4	9.0	12.7
Tibia							
Settlement (m-l)	$t = 9.00$	71	11.5	1.2	9.1	13.9	10.2
Traditional (m-l)	$p < .000$	23	9.5	0.8	8.6	11.6	8.8
Settlement (a-p)		71	12.3	1.4	8.9	14.9	11.5
Traditional (a-p)		23	10.6	1.2	7.9	13.6	11.4

tition. Descriptive statistics (number, mean, standard deviation, minimum, maximum, coefficient of variation [Cv]) for the limb-bone measurements are given in Table 2. Scatter plots of the midshaft diameters of each chronological group are shown in Figure 3. The small sample size of humeri and tibiae Expansion period groups resulted in their exclusion from analysis. Frequency classes of tooth-wear scores, using combined mandible and maxilla tooth rows, are shown in Figure 4.

Limb-bone statistics indicate that the smallest diameters occur in Expansion (middle) and Traditional group (late prehistoric) dogs and the largest in dogs from Settlement sites (early prehistoric). Figure 3 shows that although there is an overlap between early and late groups' limb dimensions, this is largely restricted to the lower section of the Settlement midshaft distribution (see Figure 3 and Plate 1). Both humeri and tibiae have two outliers from the late prehistoric group that extend well into the upper range of the Settlement group. These specimens belong to individuals from Murdering Beach. To determine the statistical significance between the temporal groups, a *t*-test was applied to the humeri and tibiae data. For the radii, one-way analysis of variance using a fixed-effects model was undertaken. As midshaft dimensions are highly correlated (humerus $r = 0.85$, radius $r = 0.81$, tibia $r = 0.85$), only the medio-lateral significance results are reported (Table 2). All test results were highly significant. The Scheffe multiple comparison test identified that, as expected from the mean values, radii from the Settlement group were different ($p < .05$) from Expansion and Traditional groups. Heterogeneity of variance (using Bartlett's-Box) was found in the case of the radii (a-p) data.

Tooth wear from early prehistoric Settlement dogs is slight, with most individ-

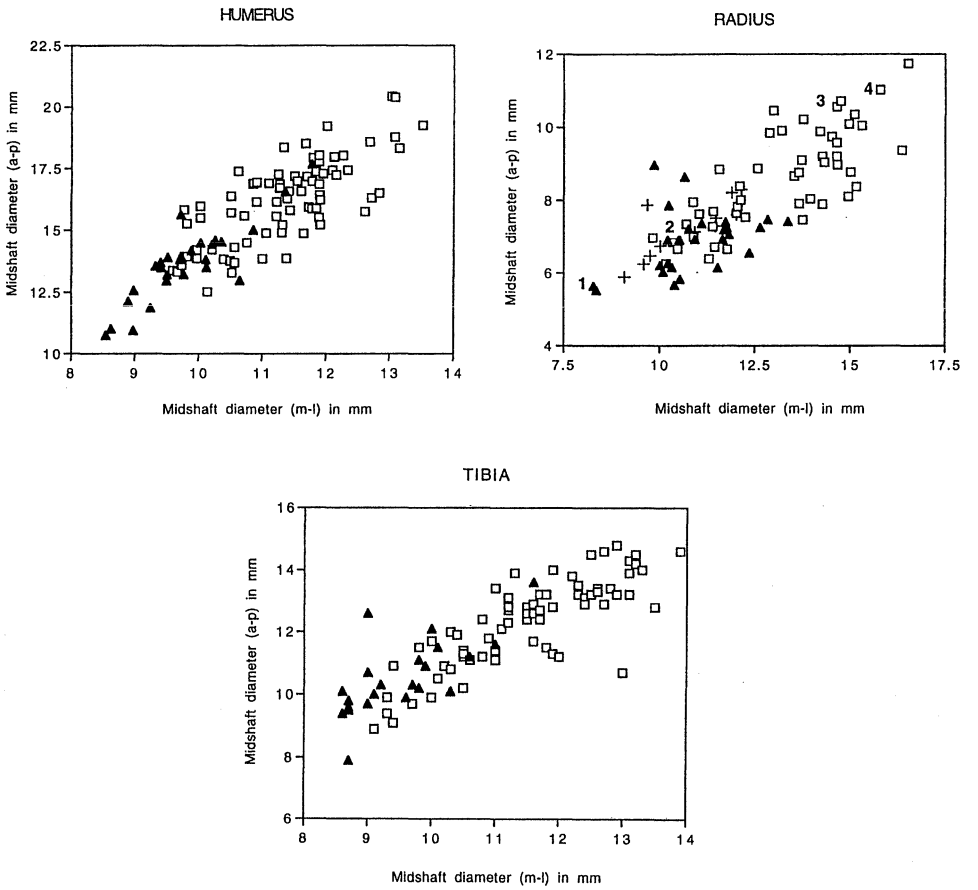

Fig. 3. Scatter plots of *kuri* midshaft dimensions (anterior-posterior, medio-lateral) for three limb bones. Graph symbols: square = Settlement; cross = Expansion; filled triangles = Traditional. See Plate 1 for explanation of numbers (1–4) on radius plot.

uals having a score of either 1 (68.4 percent) or 2 (17.6 percent). A similar pattern is found for the Expansion group, with 81.1 percent having a combined score of 1 and 2. This pattern is reversed in dogs from Traditional groups, which have 86.3 percent of individuals with tooth-wear scores of 3 or greater.

Unequal sample size between groups is probably due to reasons such as a change in husbandry practices (Allo Bay-Petersen 1979) and the intensive use of *kuri* bone for artifact manufacture in late prehistory (see Fisher 1934).

DISCUSSION

Limb-bone dimensions

Temporal variation in the diaphysis of prehistoric human populations is often used to infer a change in activity type or duration (Bridges 1989:387; Larsen 1981). The changes to subsistence and physical activities involved in the transition from hunting and gathering to agriculture is accompanied, although not in

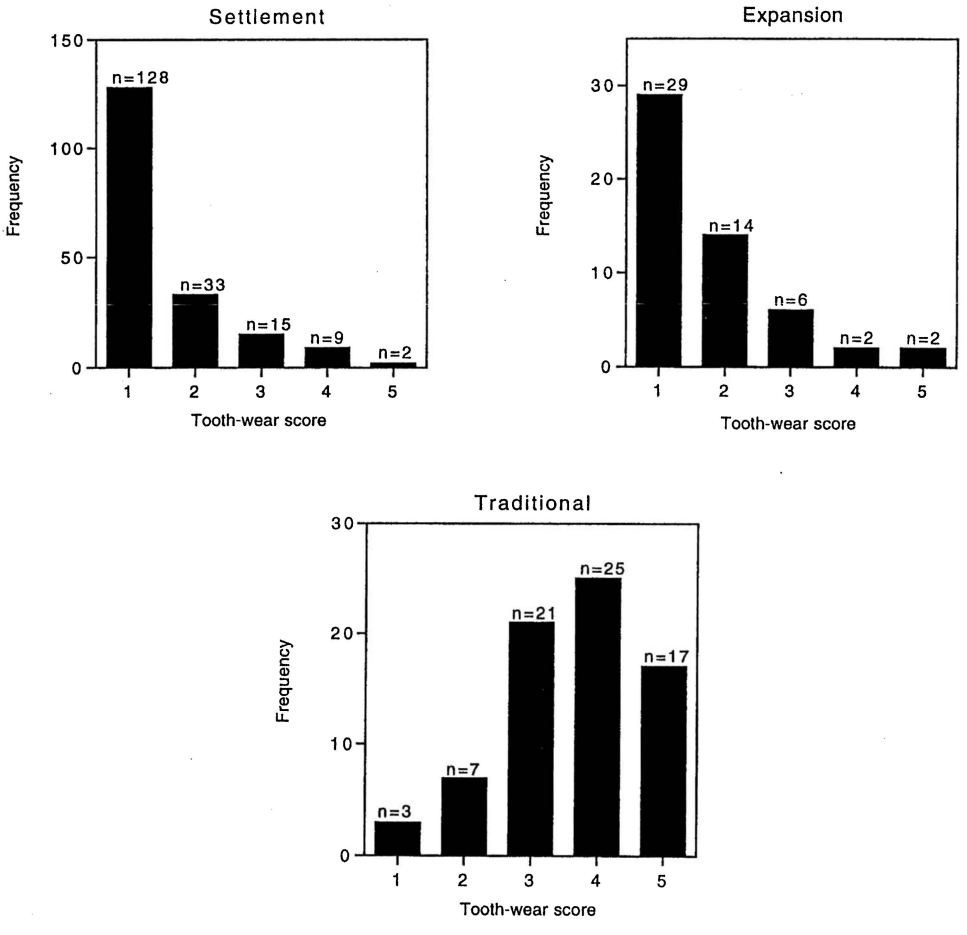

Fig. 4. Frequency graphs of *kuri* tooth-wear scores by chronological group.

all cases, by a decrease in the cortical bone thickness and the diaphysial diameter of the upper and lower limbs (Larsen 1987; Ruff et al. 1984). Studies of human and other vertebrates have shown that the diaphysis is sensitive to changing activity levels (Lanyon et al. 1982; Rubin and Lanyon 1984; Trinkaus et al. 1994).

In addition to being influenced by activity levels, limb-bone shaft circumferences and diameters are highly correlated with an animal's age and body weight (Andersen and Floyd 1963; Anderson et al. 1985; Ruff et al. 1991). An individual's weight is intimately connected with its nutritional intake. Studies of prehistoric human groups show that poor nutrition can cause a decrease in cortical bone thickness as limb length is maintained at the expense of shaft strength (Larsen 1987 : 349). A major effect of inadequate nutrition is that normal growth rates are slowed and final stature and body size is reduced (Brothwell 1981 : 163). Further, there is evidence that reliance on a limited range of food resources, such as maize, has a profound effect on growth and development and that reduced stature, cortical thinning, and smaller overall size is the end result of a poor nutritional history (Kimura 1984; Larsen 1987 : 349).

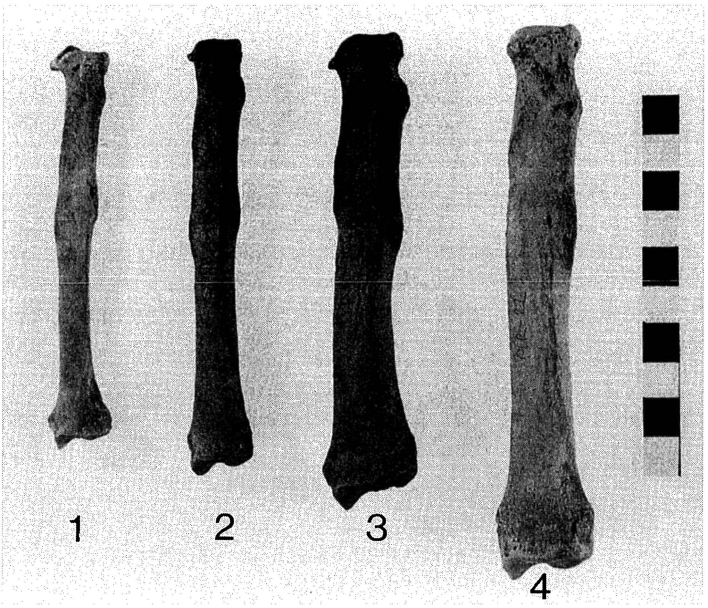

Plate 1. Caudal view of *kuri* (right) radii. From left to right: one Traditional (1) and three Settlement (2, 3, 4) radii. See Figure 3 for scatter plot dimensions of these specimens (scale bar in cm).

Pardoe (1984 : 22) notes that biological anthropologists tend to see all skeletal variation as having a genetic cause, whereas the effect of climate on morphology may be important. It is unlikely that latitudinal variation is responsible for the pattern of *kuri* diaphysial change, as most cranial dimensions were not significantly different between either North and South Island dogs or Settlement and Traditional groups (Clark 1995).

The reduced midshaft limb diameters of Expansion and Traditional *kuri* might be the result of a change to activity levels caused by the reduction of their range around permanent or semipermanent settlements, as Maori subsistence strategies changed from a focus on hunting and gathering to a more sedentary horticulturally based lifestyle (Davidson 1984 : 166–170; McGlone et al. 1994). There is, however, no mention in the ethnographic literature of any instance of tethering or penning of *kuri*, as recorded for Hawaiian dogs (Ellis 1979), although it is worth noting that archaeological evidence for tethering *kuri* is occasionally claimed (Cassels n.d.; Nichol 1988).

An alternative is that *kuri* suffered a change in the type or quantity of its diet through time. To look at the question of a change in nutrition in more detail, it is necessary to examine the results of *kuri* tooth wear.

Tooth wear and diet

The link between subsistence and dental attrition (abrasion or tooth wear) has often been remarked upon (Chappel 1927; Smith 1972; Turner 1979). Wear on the anterior teeth in prehistoric human populations is thought to represent the

use of the teeth in food preparation or industrial activities, whereas wear on the molar teeth more accurately reflects the individual's diet (Littleton and Frohlich 1993 : 433; see, however, Larsen 1987 : 403–409). Severe molar wear is often caused by a diet in which there is a high proportion of grit and/or sand (Chaplin 1971; Pedersen 1947; Powell 1985; Turner 1979).

Evidence that a temporal change in prehistoric Maori subsistence could be discerned in the dentition of human remains was informally noted by Trotter (1972) and detailed by Houghton (1978). Early prehistoric Maori dentition had slight wear compared to the extensive wear found in late prehistoric remains. Fern root (*Pteridium esculentum*) and shellfish (dried or undried) were two foods that probably contributed to severe tooth wear. However, Olsen (1981) found that the antiquity of the human remains did not appear to be correlated with the degree of dental attrition.

Allo (1971) noted that severe tooth wear was prominent in late prehistoric dogs from the South Island. The results of the present study demonstrate that some late prehistoric dogs from the North Island also suffered considerable dental attrition. It has been suggested by Allo (1970 : 117–130) that diet and husbandry practices changed in late prehistory, resulting in dogs being kept longer before being killed. While it is probable that husbandry practices did change through time, it is unlikely that this was completely responsible for the severe tooth wear. This is suggested by late prehistoric specimens with recently erupted permanent cranial and mandibular dentitions already displaying extensive tooth wear (at Kohika and Murdering Beach).

Kuri *Diet*

Kuri diet through prehistory can be partially reconstructed using archaeological and ethnographic data. Signs of dog gnawing have been identified on the prehistoric remains of sea mammals, dogs, birds, fish, and moa (Allo 1970; Kooyman 1985; Nichol 1988; Taylor 1984; Trotter 1975). Fish bones are a common component of early and late prehistoric *kuri* coprolites, but moa, small bird bones, and shellfish are also found occasionally (for a review, see Clark 1995 : 18). However, the assumption that coprolite contents accurately reflect the *kuri* diet needs to be treated with caution as studies have shown that digested bone survives differentially. There is a tendency for the bones from smaller species, such as fish, to survive intact in comparison to the bones of larger animals, which require heavy grinding and chewing to process (Jones 1986). Experiments to assess canine-gnawing on large bones show that there is often little evidence left to indicate that meat and cartilage were removed (Haynes 1980 : 343; Kent 1981).

Evidence of a dietary change through time is indicated by the tooth-wear results. Early prehistoric sites with evidence of diverse faunal remains (e.g., Kaupokonui, Houhora, Shag Mouth) would have provided *kuri* with a substantial quantity and range of meat foods. Maori husbandry may have involved either the deliberate feeding to *kuri* of butchery off-cuts from seals, moa, and other fauna or *kuri* scavenging from midden debris. The overhunting of seal and moa populations (Anderson 1989; Smith 1985), in conjunction with the diminished fauna remaining after Maori deforestation (Holdaway 1989), appears to have had a sig-

nificant affect on *kuri* diet in postcolonization times. Historical records (Allo Bay-Petersen 1979; Titcomb 1969) suggest that at European contact marine foods, especially fish, were a major component of *kuri* diet.

It appears likely, therefore, that late prehistoric *kuri* suffered severe tooth wear from a marine diet containing a high proportion of sand and grit, which resulted in advanced dental attrition. However, this finding does not by itself explain the reduced diaphysial dimensions of this group. Marine foods have been found to provide better balanced sources of nutrients to dogs than most meats (Hedhammer 1982). If the quality of *kuri* food sources is not responsible, then a decrease in the quantity of food may be a reasonable alternative. This conclusion might also be suggested by the Expansion radii diaphysis and Expansion tooth-wear results, which show that there has been a reduction in midshaft dimensions while the degree of tooth wear is still small. Perhaps, these results represent the depletion of the suite of easily exploitable game, resulting in a diet that is still characterized by a broad range of fauna, but in which there is less quantity available. However, because of the small sample size available for the radii ($n = 11$) there is insufficient information available to investigate this proposition in detail.

In this analysis, the *kuri* appendicular limb shaft dimensions reflect environmental conditions, particularly the nutritional conditions in which *kuri* lived. As Reitz and Ruff note (1994 : 709): "Typically, body size is an indication of health and reflects both nutritional state and presence or absence of disease."

Interestingly, it was noted during analysis that there was a consistent pattern in which *kuri* from Settlement sites in southern New Zealand, such as those from Shag Mouth and Pleasant River, had the greatest length and midshaft diaphysial dimensions, indicating that they lived in a plentiful nutritional environment. The size and frequency of early Maori sites on the east coast of southern New Zealand has for some time indicated (Cumberland 1962 : 158, 161) the abundant faunal resources of this area (see also Anderson 1989 : Figs. 8.1, 9.1, 10.1). As a result, it seems that *kuri* from southern New Zealand reached their greatest body size and weight, in contrast to prehistoric dogs elsewhere in Polynesia and New Zealand (Clark unpublished data). The presence of larger than average individuals among the *kuri* from the Murdering Beach site raises the possibility that some dogs were preferentially treated in late prehistory. This might occur through association with people of high status or could result from a phenotypic character that was highly valued by Maori, such as coat color.

Temporal changes, whether in artifact styles, subsistence behavior, or resource exploitation, are well recognized in New Zealand (e.g., Duff 1956; Golson 1959; Green 1975; Hjarno 1967). These general patterns of change can act to obscure archaeological understanding at a regional and interregional level, and the results from this study are no exception. It is apparent, for example, that while marine foods were important to late prehistoric Maori economies, horticultural products were also heavily utilized in some regions (Leach 1984). It is unclear whether some groups of *kuri* were fed on vegetable foods, such as fern root, sweet potato (*Ipomoea batatas*), or cabbage tree (*Cordyline australis*), and what archaeological signature such a diet would leave on the dentition. A vegetable diet high in starches and sugars led to frequent dental caries in the molar teeth of the Hawaiian dog (Svihla 1957). Caries appeared to be absent in all mandibular and maxillary denti-

tions examined in this study (cf. Allo 1971 : 39), although abscessing caused by infection of the exposed pulp cavity, which can resemble caries, was present in several dentitions with a high degree of tooth wear.

Not all late prehistoric dogs have severe tooth wear (see Leach and Hamel 1978 : 245) and some of those from sites classed as Settlement have high tooth-wear scores and gracile limb bones. For example, dogs from Purakaunui (Anderson 1981*a*), dating to the fourteenth century (NZ 4746, NZ 4748), have small post-cranial dimensions and higher tooth wear than those from nearby sites of comparable antiquity. However, fish and shellfish contributed 93 percent of the meat weight represented at this site (Smith 1985 : 190), adding some supporting evidence for the cause of diaphysial and dental variation, but suggesting that important local differences, possibly linked to site function, are likely to exist along with a major temporal component of *kuri* variation.

CONCLUSION

The skeletal changes in the *kuri* post-cranial skeleton that demonstrate variation over time match those identified in commensals in other parts of the world (Harcourt 1974; Higham 1968; Teichert 1984). The New Zealand case is instructive in that significant variation appears to occur within a relatively short time span of about 200–400 years. *Kuri* skeletal and dental information matches archaeological evidence for a rather abrupt change in Maori subsistence during prehistory (Davidson 1984; Lockerbie 1959; McGlone et al. 1994). At least for the *kuri*, it is apparent that the abundant faunal resources of New Zealand at colonization and especially in areas of the east coast of the South Island enabled the attainment of large body size and weight. These resources may well have fuelled rapid population growth and this is also suggested by plentiful *kuri* remains found in Settlement sites. In late prehistory, growth rates are likely to have slowed and mean population body weight diminished in response to a reduced food supply.

Physical anthropologists have documented various environmental and cultural factors that probably affected the skeletal form of human prehistoric populations in Oceania (Houghton 1980, 1991; van Dijk 1991; Visser 1994*b*). The results of this study indicate that nutrition can have a significant effect on limb-bone dimensions (see Visser 1994*a* : 246), although a change in activity levels might be an important component of *kuri* diaphysial variability. Whether the decrease in dimensions noted in the *kuri* appendicular skeleton over time also occurred in the New Zealand prehistoric human population is unclear. The *kuri*, as both the single Maori commensal and as a preferential carnivore, might be expected to suffer a dietary change out of proportion to that experienced by the Maori population. If this is so, then the *kuri*'s midshaft dimensions and degree of tooth wear provide evidence, not necessarily of a catastrophic nutritional change, but of a new orientation by Maori toward a changing resource base (see Anderson and Smith 1996).

It is notable that there has been negligible crossing of research boundaries by physical anthropologists and zooarchaeologists. But both are involved in the examination of skeletal remains from archaeological sites. In the former case it is the study of human remains, and in the latter case it is commensal and noncommensal species that are examined. The current study demonstrates the utility of a

broad approach using biological information obtained from both disciplinary perspectives. The correlation between skeletal characteristics (e.g., palaeopathology, quantity of metrical skeletal variation, dental wear) of commensal species and their expression in human "host" groups is a fruitful area for future crossdisciplinary research.

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ABSTRACT

The dental wear and the post-cranial dimensions of the prehistoric dog of New Zealand (*kuri*) are shown to reflect the Maori environment in which it lived. Mid-shaft dimensions became smaller and tooth wear advanced in late prehistoric groups. Nutrition is likely to have been the single most important causative factor in the observed temporal shift. The changes match archaeological evidence for a subsistence move by Maori away from large game taxa toward a focus on marine and horticultural products. It is suggested that there is potential for profitable collaboration between zooarchaeologists, studying commensal species, and physical anthropologists involved in the analysis of prehistoric human remains. KEYWORDS: Maori, dog, *kuri,* skeletal variation, tooth wear, New Zealand.